

ABS side thereof. **FIG. 35** shows only the central portion of the device sectioned in an XZ plane.

[0562] The magnetoresistive-effect device is a spin-valve type thin-film device, namely, one type of GMR (giant magnetoresistive) devices making use of the giant magnetoresistive effect. The spin-valve type thin-film device is mounted on the trailing end of a floating slider in a hard disk device to detect a magnetic field recorded onto a hard disk. The direction of the movement of a magnetic recording medium such as a hard disk is aligned with the Z direction, and the direction of a leakage magnetic field of the magnetic recording medium is aligned with the Y direction.

[0563] A substrate **319**, fabricated of a nonmagnetic material such as Ta (tantalum), becomes the bottom layer of the device as shown in **FIG. 35**. An antiferromagnetic layer **320**, a pinned magnetic layer **312**, a nonmagnetic electrically conductive layer **313**, and a free magnetic layer **314** are laminated onto the substrate **319**. A protective layer **315**, fabricated of Ta (tantalum), is formed on the free magnetic layer **314**. A multilayer film **316** thus includes the substrate **319** through the protective layer **315**. Referring to **FIG. 35**, the width dimension of the top surface of the multilayer film **316** is T30.

[0564] The pinned magnetic layer **312** is deposited on and in direct contact with the antiferromagnetic layer **320**, and is subjected to annealing in the presence of a magnetic field. An exchange anisotropic magnetic field takes place through exchange coupling at the interface between the antiferromagnetic layer **320** and the pinned magnetic layer **312**. The magnetization of the pinned magnetic layer **312** is thus pinned in the Y direction.

[0565] In accordance with the present invention, the antiferromagnetic layer **320** is made of a Pt—Mn (platinum-manganese) alloy film. The Pt—Mn alloy film outperforms an Fe—Mn alloy film and Ni—Mn alloy film, conventionally used as an antiferromagnetic layer, in terms of corrosion resistance, and has a high blocking temperature, and further provides a large exchange anisotropic magnetic field (Hex). The Pt—Mn alloy film has thus excellent characteristics as an antiferromagnetic material.

[0566] Instead of the Pt—Mn alloy, the antiferromagnetic layer **320** may be made of an X—Mn alloy where X is a material selected from the group consisting of Pd, Ir, Rh, Ru, and alloys thereof, or a Pt—Mn—X' alloy where X' is a material selected from the group consisting of Pd, Ir, Rh, Ru, Au, Ag, and alloys thereof.

[0567] The pinned magnetic-layer **312** and the free magnetic layer **314** are made of an Ni—Fe (nickel-iron) alloy, Co (cobalt), an Fe—Co (iron-cobalt) alloy, or an Fe—Co—Ni alloy, and the nonmagnetic electrically conductive layer **313** is made of a low electrical-resistance nonmagnetic electrically conductive material, such as Cu (copper).

[0568] Referring to **FIG. 35**, hard bias layers **317** and **317** are formed on both sides of the multilayer film **316**, composed of the substrate **319** through the protective layer **315**. The hard bias layers **317** and **317** are made of a Co—Pt (cobalt-platinum) alloy or a Co—Cr—Pt (cobalt-chromium-platinum) alloy.

[0569] The hard bias layers **317** and **317** are magnetized in the X direction (i.e., the direction of a track width), and the

magnetization of the free magnetic layer **314** is aligned in the X direction under the bias magnetic field in the X direction from the hard bias layers **317** and **317**.

[0570] Intermediate layers **321** and **321**, made of a high-resistivity material having a resistance higher than that of the electrode layers **318** and **318** or an insulating material, or a laminate of a high-resistivity material and an insulating material, are separated from the hard bias layers **317** and **317** by antimagnetic layers **323** and **323**. When an oxide or Si compound is used for the intermediate layer **321**, the antimagnetic layer **323** is preferably interposed between each of the hard bias layers **317** and **317** and each of the electrode layers **318** and **318**. Without the antimagnetic layer **323**, diffusion is likely to take place between the hard bias layers **317** and **317**, made of CoPt, and the intermediate layers **321** and **321** made of the oxide or Si compound. When the intermediate layers **321** and **321** are constructed of an N compound, however, such a diffusion is less likely to take place, and the antimagnetic layer **323** is dispensed with.

[0571] The high-resistivity material **321**, which fabricates the intermediate layer **321**, is preferably at least one material selected from the group consisting of TaSiO₂, TaSi, CrSiO₂, CrSi, WSi, WSiO₂, TiN, and TaN.

[0572] Furthermore, the high-resistivity material, which fabricates the intermediate layer **321**, is preferably at least one material selected from the group consisting of Al₂O₃, SiO₂, Ti₂O₃, TiO, WO, AlN, Si₃N₄, B₄C, SiC, and SiAlON.

[0573] Referring to **FIG. 35**, the electrode layers **318** and **318** are deposited on nonmagnetic materials **234** and **324**, made of Ta, which are respectively deposited on top of the intermediate layers **321** and **321**. In the twentieth embodiment, the electrode layers **318** and **318** are formed to extend over the multilayer film **316**. When an oxide or Si compound is used for the intermediate layers **321** and **321**, the use of the nonmagnetic material **234** and **324** is preferable. When an N compound is used for the intermediate layers **321** and **321**, whether to use the nonmagnetic material **234** and **324** is not important.

[0574] Since the electrode layers **318** and **318** are formed to extend over the multilayer film **316**, the electrode layers **318** and **318** are connected to each other through the multilayer film **316**. The electrode layers **318** and **318** are made of Ta (tantalum) or Cr (chromium).

[0575] Since the intermediate layers **321** and **321**, made of at least one of a high-resistivity material having a resistance higher than that of the electrode layers **318** and **318** and an insulating material, are interposed between each of the hard bias layers **317** and **317** and each of the electrode layers **318** and **318**, the sense current from the electrode layer **318** is less likely to flow into the hard bias layer **17**. The percentage of the sense current shunting into the hard bias layer **317** is thus reduced.

[0576] In accordance with the present invention, the electrode layers **318** and **318** are formed to extend over the multilayer film **316**, and the sense current directly flows from the electrode layer **318** formed on the multilayer film **316** into the multilayer film **316** without passing through the hard bias layer **317**, because of the presence of the intermediate layers **321** and **321**. The magnetoresistive-effect device of this invention thus enhances the reproduction gain,